Protocol
1A3c: CO_2, N_2O, and CH_4 from Rail transport

IPCC Category:	1A3c
NFR Code:	1A3c
NOSE Code:	202.01
NACE Code 2008	4910 and 4920

Foreword
Under the Kyoto Protocol, the Netherlands is required to set up and maintain a national system to monitor its greenhouse gas emissions. One of the elements of this system is a transparent and verifiable description of the methods and processes used in this monitoring system. These methods must meet international guideline criteria, which have been defined by the United Nations (UN) and the European Union (EU).

The Netherlands meets the aforementioned requirement, for example, by defining a series of Monitoring Protocols, which describe the methods and work processes used to determine greenhouse gas emissions and the amounts of carbon sinks available. Protocols have been written for about 40 greenhouse gas sources or sinks. This document describes the protocol for one of these sources or sinks.

The protocols have been compiled in close collaboration with experts from various sectors of society in the Netherlands, particularly experts from the Emissions Registration (ER). The ER is a collaborative group that includes institutions such as CBS, WUR, RIVM and PBL. Until 31 December 2009 this was coordinated by PBL (Planbureau for the Leefomgeving, or the Netherlands Environmental Assessment Agency), but on 1 January 2010 this coordination task was taken over by RIVM (the Netherlands institute for public health and the environment). Other institutions that have contributed to the protocols include NL Agency; Ministry of Agriculture, Nature and Food Quality; and the Ministry of VROM (Housing, Spatial Planning and the Environment).

1 Scope and significance of emission sources/activities

1.1 Scope and definition
This protocol describes the methodology for calculating CO_2, N_2O, and CH_4 emissions as a result of combustion of diesel fuel in rail transport (IPCC-category: 1A3c; SBI-code: 4910 and 4920). The emissions resulting from the use of electric energy by rail transport are accounted for in the emission figures of the energy production sector.

The share of diesel locomotives in the total passenger transportation is less than 10%. The major part of freight transport is carried ou with diesel locomotives. Exact figures are not known.

1.2 Significance and influences

1.2.1 Contribution to total national emissions
The emissions of CO_2, CH_4 and N_2O by rail transport, each contribute less than 0.1% to the Netherlands annual greenhouse gas emissions.

1.2.2 Major developments that infuence emissions

There are no substantial developments affecting the emissions.

2 Method, emission factors and activity data

2.1 Calculation method

The emissions by rail traffic are calculated by multiplying the fuel consumption by emission factors.

Emission (kg) = fuel consumption (kg) * emission factor (gram/kg) * 10^{-3}

The background figures used to calculate CO_2, N_2O and CH_4 emissions from railway vehicles are published annually and updated in a *set of tables* that accompany the methodology report for mobile sources [Klein et al.]. Each table in the set states which source is used for the figures. The methodology report itself contains a detailed description of the way in which emission factors and emissions are calculated.

The fuel consumption figures are published in Table 5.1 of the *set of tables*. The emission factors are shown in Table 5.2.

2.2 Emission factors

The tables below show the used emission factors and fuel conversion factors. The emission factors, expressed in grams of emissions per kg of combusted fuel, are ascertained by PBL (the Netherlands Environmental Assessment Agency - formerly the National Institute for Public Health and the Environment) in consultation with the former NS. See also *Table 5.2* in the excellsheet, belonging to the methodology report [Klein et al].

CO_2-emission factors IPCC

	Specific heat *(MJ/kg)*	**CO2 EF** *(gram/MJ)*	**CO2 EF** *(gram/kg)*
Diesel fuel	42,7	74,3	3173

Source: Vreuls, 2006

IPCC Default factors N_2O en CH_4

	N_2O EF *(gram/MJ)*	**N_2O EF** *(gram/kg)*	**CH_4 EF** *(gram/MJ)*	**CH_4 EF** *(gram/kg)*
Railways	0,0006	0,02562	0,005	0,2135

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories; Reference Manual p. 1.35 and p.1.36 (IPCC, 2007)

2.3 Activity data

The fuel consumption data originate from Dutch Railways (NS-Reizigers). which is responsible for purchases of diesel fuel. The fuel data are published in table 5.1 in the excellsheet, belonging to the methodology report [Klein et al].

3 Working processes

Process for estimating (t-1)
The ER produces annual preliminary emission figures for the previous year (T-1). These preliminary data are calculated by extrapolating the figures from the previous year, based on the development prognoses for the most important activity data (derived from CBS and other statistics).

Process for final determination of (t-2)
The final emission figures (as described in this protocol) are calculated using the following process.

INPUT	PROCESS	OUTPUT	BY WHOM
NS-figures[1)] on fuel consumption . **(A)** Emission factors (g/kg) **(B)** [2)]	**(A) x (B_{CO2})** **(A) x (B_{N2O})** **(A) x (B_{CH4})**	CO_2, N_2O, and CH_4 emissions by rail transport **(C)** Final data Work package leader (t-2)	Statistics Netherlands
Final data Work package leader (t-2)	Include (t-2) data in ER database	ER-db with (t-2) data	Work package leader
ER-db with (t-2) data	Check, and trend analysis of air emissions: explain deviations or modify figures	Final defined emission figures (t-2)	Task forces and PBL experts

[1)] NS = Dutch Railways
[2)] IPCC-factors.

4 Uncertainty and quality

4.1 Estimating uncertainties

A Tier-1 uncertainty analysis is implemented every year before the NIR is submitted by the ER, based on the greenhouse gas inventory and in compliance with IPCC guidelines. The assumptions used and the results thereof are described in a background report to the NIR. In addition to this, where included in the QA/QC programme for the relevant period, extra analyses are implemented regularly in specific situations, which include any updating of the Tier-2 uncertainty analyses.

The Tier-2 uncertainty assessment was last updated in 2006. This assessment showed that a Tier-1 uncertainty assessment is sufficiently reliable and that Tier-2 uncertainty assessments need only be implemented at periodic intervals of around 5 years, unless a major change in an important source is sufficient to require earlier reassessment.

- Source-specific uncertainty
The uncertainty estimate-totaal concerns the root of the sum of uncertainty in the data sources used (AD_{onz}) in the square and the uncertainty of the emission factor (EF_{onz}) in the square.

The extent of the total uncertainty is here primarily determined by the greatest AD or EF uncertainty.

$$\text{Uncertainty estimate}_{\text{total}} = \sqrt{EF_{onz.}^{2} + AD_{onz.}^{2}}$$

The uncertainty estimates concerning the data sources (AD) and emission factors (EF) used, and the total uncertainty estimate, are listed in the following table.

IPCC	Category	Gas	$AD_{onz.}$	$EF_{onz.}$	Uncertainty estimates $_{tot}$
1A3	Mobile combustion: other (railways)	CO_2	5	0.2	5
1A3	Mobile combustion: other (non-road)	CH_4	50	100	112
1A3	Mobile combustion: other (non-road)	N_2O	50	100	112

Activity data (AD) and emission factors (EF)
For the uncertainty in the activity data and CO2 emission factor for railways the same value was chosen as that for diesel in road transport, respectivily 5 and 0,2%. The uncertainty in activity data for CH4 and N2O was estimated at 50%. The uncertainty in the CH4 and N2O emission factor was estimated at 100% [Olivier et al, 2009].

Annual emissions
The uncertainty in CO_2 emissions from railways was estimated to be about 5% in annual emissions from railways. The uncertainty in CH_4 and N_2O emissions from non-road transport (c.q. railways) was estimated to be about 100% in annual emissions. Data on the share of CH_4 in total VOC were based on information in Veldt and Van der Most (1993) and have not been validated since [Olivier et al, 2009].

4.2 Quality assurance and quality control (QA/QC)

The ER work package leaders check that:

1. the basic data are well documented and adopted (check for typing errors, use of the correct unit sizes and correct conversion);
2. the calculations have been implemented correctly;
3. assumptions are consistent, also whether specific parameters (e.g. activity data) are used consistently;
4. complete and consistent data sets have been supplied.

Any actions that result from these checks are noted on an ‘action list’. Before defining the data, supervisors check whether the relevant actions on this list, plus the QC checks, have all been completed. Defining the data is carried out by the WEM (working group on emissions monitoring), and confirmed in writing via an e-mail from the institute representatives to the ER project leader at PBL.

The work package leaders fill out a new documentation sheet when adding new data. For reasons of efficiency a minimum level has been set for obligatory documentation, i.e. 5% changes at target group level, and 0.5% at levels concerning the national total. These documentation sheets form part of the trend analysis, as well as the eventual definition of the data set.

The ER work package leaders communicate by e-mail regarding these QC checks, results and actions. They send a printed copy to the ER secretary, who keeps a logbook and compiles these e-mails into an 'action list'. This shows explicitly that the required checks and corrections have been carried out.

4.3 Verification

In order to check the quality of the emission figures for the sources in this protocol, general QA/QC procedures have been followed that are in line with the IPCC guidelines. These are described further in the QAQC programme used by the National System, and the annual working plans published by the ER.

- Sector-specific QC

No additional specific verification procedures are implemented for the sources defined in this protocol.

4.4 Possibilities for improvement compared to the current calculation method

4.4.1 History

Not applicable

4.4.2 Future

Not applicable

5 Remaining aspects

5.1 Point source criteria

Not applicable

5.2 Component profiles

Not applicable

5.3 Regionalisation

Not applicable

5.4 Time-based variations in source strength

Not applicable

6 References and additional information

6.1 References

- IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Emission Inventories, Three volumes: Reference Manual, Reporting Guidelines and Workbook. IPCC/OECD/IEA. IPCC WG1 Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK
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- Klein, J.A.P. e.a. (CBS, PBL, RWS-Waterdienst/Deltares, RWS-DVS, TNO-M&L, TNO-EST), Methods for calculating the emissions of transport in the Netherlands. The report, including the tables in the Excelfile, can be found on: http://www.cbs.nl; choose: Thema's

/ Natuur en Milieu / Methoden / Onderzoeksbeschrijvingen / Aanvullende onderzoeksbeschrijvingen. The Methodoly Report and the tables in the Excelfile are being updated once a year
- Olivier J.G.J., L.J. Brandes and R.A.B. te Molder, 2009 (in print) Uncertainty in the Netherlands' greenhouse gas emissions inventory: Estimate of annual and trend uncertainty for Dutch sources of greenhouse gas emissions using the IPCC Tier 1 approach, PBL-Report 500080013, Bilthoven
- RIVM/LAE, Notitie E.Rab over informatie van NS over emissiefactoren voor dieselgedreven materialen, Bilthoven, 1993
- Veldt, C. and P.F.J. van der Most (1993) Emission factors: VOC from combustion engines (in Dutch). Report Series Emission Registration no. 10, VROM The Hague, April 1993.
- Vreuls H.H.J., The Netherlands: list of fuels and standard CO_2 -emission factors, SenterNovem, 2006

6.2 Additional information

Not applicable